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THE PURCHASE OF COAL UNDER GOVERNMENT
AND COMMERCIAL SPECIFICATIONS ON THE
BASIS OF ITS HEATING VALUE

WITH ANALYSES OF COAL DELIVERED UNDER
GOVERNMENT CONTRACTS

BY

D. T. RANDALL



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THE PURCHASE OF COAL UNDER GOVERNMENT AND COMMERCIAL SPECIFICATIONS ON THE BASIS OF ITS HEATING VALUE.

By D. T. RANDALL.

INTRODUCTION.

The people of this country have been purchasing coal for years on the statement of the selling agent as to its quality, or on the reputation of the mine or district from which it was obtained. The farmers of the country show more business judgment in the purchase of fertilizer than do many manufacturers in buying coal, for the farmer demands a chemical analysis of the fertilizer before he accepts it.

Until recently there has been but little reliable information regarding the character of the coal supply of the United States. This fact was recognized in the establishment of the fuel-testing plant of the United States Geological Survey at St. Louis in 1904. Extended general investigations have been conducted at this plant and its successors and in the field, and in addition the technologic branch of the Survey has been charged with the duty of analyzing and testing the coals used by the Government.

The Government is a large purchaser of coal, reports from the various Departments indicating that nearly \$6,300,000 is expended each year for fuel. Some time ago the necessity for a more uniform standard in the purchase of coal became apparent and the plan of buying it on the basis of its heating value was introduced in a few Departments. Many of the large commercial consumers in the United States have been purchasing their coal on contracts of this nature for some time.

The present paper summarizes the information on this subject obtained by the Survey, including examples of specifications that are now in use and analyses of some of the coal purchased by the Government during the winter of 1906-7.

ADVANTAGES OF DEFINITE SPECIFICATIONS IN THE PURCHASE OF COAL.

Under the old plan of purchasing coal, when the consumer had cause or thought he had cause to find fault with the quality of the fuel he received, he was in many cases assured that it must be good because, like all the other coal sent him, it came from a mine with an established reputation. Such a state of affairs made it difficult to take advantage of the competition which usually results when a considerable number of bidders are asked to submit prices. The purchaser was afraid to buy from any but such dealers as he knew and trusted, because, although each dealer claimed that his coal was equal in quality to that of the others, yet if it did not prove to be satisfactory there was no standard for settlement or for cancellation of the contract. Many thousands of dollars' worth of coal are bought each year in this manner, but the purchasers would consider it ridiculous if they were asked to contract for a building with no specifications and simply on the agreement that it should be of a certain size and well constructed. Neither would they buy gold, silver, or even copper and iron ores on the mere information that they were mined at certain localities. All products of mines are now purchased to a great extent on the basis of their value as shown by chemical analysis. This is true of coal in only a small degree, but the number of contracts made on this basis is increasing every year.

The purchase of coal on a specification is as advantageous as a definite understanding regarding the quality and other features of any other product, or of a building operation or engineering project. The man who buys under a specification gets what he pays for and pays for what he gets.

When the bidder is allowed to specify the quality of the coal he proposes to furnish as determined by a chemical analysis, he is placed on a strictly competitive basis with other bidders. Such a procedure broadens the field for both the bidder and the purchaser. It makes the bidder's proposal, when accepted, a contract that specifies an established standard of quality. This furnishes a basis for settling disputes regarding the quality of the coal delivered and the price to be paid if the fuel is either better or poorer than has been guaranteed. If other coal must be substituted, as often happens, there is a standard for settlement. If the coal is uniformly poorer than the standard as specified there is a basis for cancellation of the contract.

The quality of coal from a given mine may vary from time to time through the failure of the miners to reject impurities. Sometimes different beds of coal are mined at the same time and the output is mixed. When there is need of further preparation, such as picking

slate and other impurities, or jigging or washing, a great deal depends on the care used in these processes. The mining companies are responsible in a large measure for variations in the grade of prepared coal. The purchase of coal under a contract on the basis of quality stimulates the operator to make a better preparation of the coal before it is shipped to market. An example of fluctuations in quality is furnished by the tables on pages 24-26, which show variations in the ash and British thermal units in coal delivered to some of the Government Departments at Washington.

It evidently will not be satisfactory to either the buyer or the seller to establish a standard for the coal unless this liability to variation is recognized and provision made for settlement when the coal is better or poorer than the standard. Experience with any method of buying coal shows that it will seldom be rejected when of poor quality, because of the difficulty, delay, and cost of removing it from the bins. The buyer is often confronted with the alternative of burning the coal delivered or going without fuel until more can be procured. Unless the coal is very bad it is usually expedient to use it and pay a smaller price. This is also more favorable to the contractor, as to remove the coal would be costly and it would not be satisfactory as fuel to any other customer.

VALUE OF COAL AS A FUEL.

The purpose of burning coal under boilers is to abstract the heat for use in developing power, in drying various materials, or in warming buildings. The most valuable coal, therefore, is that which gives up the most heat to the boiler for a given weight burned.

Coal is now burned for power purposes in gas producers and boiler furnaces. For coals and lignites high in moisture or high in ash, the gas producer, used in connection with a gas engine, is best adapted to develop power. But for the generation of steam, which can be used for heating as well as for power purposes, a more convenient method is to burn the coal in a specially constructed furnace under a boiler.

The aim in the purchase of coal for any power plant should be to obtain a fuel which will produce a horsepower for the least cost, all things being considered, such as the equipment, the price of coal, and the cost of labor and repairs. Experiments have been made which seem to indicate that almost any fuel may be burned with reasonable efficiency in a properly designed apparatus. The recognized requirements are as follows:

A supply of fuel fed to the furnace as uniformly and continuously as possible.

An air supply slightly in excess of the theoretical amount required for complete combustion.

A sufficiently high temperature to ignite the gases which are driven off from the fuel.

A complete mixture of these gases with the air supplied before they reach a cooling surface, such as the shell or tubes of a boiler.

Some of the factors which may influence the commercial results obtained in a boiler are the cost of the coal, as determined by price and heating value; care in firing; design of the furnace and boiler setting, size of grate, etc.; formation of excessive amounts of clinker and ash; draft available; size of the coal (uniformity of size is desirable).

The value of a coal is indicated by the number of heat units it contains. This heating value is expressed in terms of British thermal units ^a (abbreviated B. t. u.) per pound of coal, and is determined by means of a special apparatus called a calorimeter.

When coal is mined it contains moisture to a greater or less extent. It is exposed to the air in shipment and may either dry out or be drenched by rain. The moisture in the coal delivered is worthless to the purchaser, and really costs him a considerable amount in freight and cartage, and in the loss of the heat absorbed during its evaporation in the furnace. If all coal had the same proportion of moisture, or if the moisture in coal delivered by a given dealer was constant in amount, the purchaser's problem, so far as this factor is concerned, would be simplified. Under present conditions the moisture is an important element in the valuation of a ton of coal. It is evidently necessary to consider the coal just as it is received in order to determine its value to the consumer, but chemical reports should be made on the basis of both the "dry coal" and the "coal as received." The dry-coal basis is convenient for comparing several coals in regard to the relation of each element to the others; this is important because the moisture in the same coal varies from day to day. The dry-coal basis is also convenient for comparing the performance of boilers when burning the same or similar coals. Of several coals having a similar composition, the one which has the least moisture and the least ash will generate the most steam when burned under a boiler.

Ash is made up of earthy matter and other impurities which will not burn. In commercial coals its proportion may range from 4 to 25 per cent. Coals containing small percentages of ash are most valuable, not only because of their correspondingly higher heating capacity, but because there is less resistance to the free and uniform distribution of air through the bed of coal. The labor and cost of managing the fires and of handling the ashes are also correspondingly

^a The British thermal unit is the amount of heat required to raise the temperature of 1 pound of water 1° Fahrenheit.

less and are items to be considered in the choice of a coal. With the ordinary furnace equipment there may be a considerable loss of efficiency and capacity through a large percentage of ash. It has been found that with some kinds of equipment, as the ash increases there is a decided drop in both efficiency and capacity. In some experiments made to determine the influence of excessive amounts of ash, coal containing as high as 40 per cent would generate no steam when fired on a chain grate, and therefore the efficiency and capacity of the plant would be zero.^a Such coal would not only be worthless, but involve a direct expense, due to the cost of handling it. Whether the result would be similar with equipment other than a chain grate has not yet been determined. However, coals so high in ash that they are unsuited to boiler furnaces can be utilized in gas producers.

The volatile part of coal as shown by the analysis may in some coals be all combustible, but it generally contains some inert matter. This varies in different coal deposits and makes it impossible to determine the heating value of the coal from the proximate analysis alone. Moreover, not all coals having the same proportion of volatile matter behave alike in the furnace. It is important to know both the chemical composition and the British thermal units in order to determine the value of one coal as compared with another for the same purpose.

Of two coals of different character, the one which contains the higher proportion of fixed carbon is most easily burned so as to give the maximum efficiency. However, if the coal containing the higher volatile matter is properly burned in a suitably designed furnace, it may be made equally efficient.

Sulphur may be present in the free state, or, as is more commonly the case, in combination with iron or other elements. Other impurities with sulphur often form a clinker which shuts out the air and increases the labor of handling the furnaces. It is possible, however, to burn coals containing up to 5 per cent of sulphur without particular difficulty from clinkers. A little steam introduced under the grate will relieve much of the trouble. Clinker may be due to other causes than sulphur, as any constituents of the ash which are easily fusible may produce it. There is need of further investigation to determine the influence of sulphur and the elements which comprise the ash on furnace fires and combustion.

The size of the coal influences the capacity of any given equipment, owing to its effect on the draft. With a poor draft fine coal can not be burned in sufficient quantities to maintain the rated capacity. If thin fires are resorted to, the efficiency is usually lowered as a result of an excessive supply of air through holes in the fire. As a

^a Abbott, W. L., Some characteristics of coal as affecting performance with steam boilers, a paper read before the Western Society of Engineers, Chicago, Ill.

rule, when dust and very fine coal are fed into the furnace they either check the flow of air or are taken up by the draft and after being only partly burned are deposited back of the bridge wall or pass up the stack, to the annoyance of the people in the vicinity of the plant. If this dust is completely burned in passing through the furnace there is of course no loss of fuel. It has been found that coal of a uniform size is most satisfactory, as it does not pack so closely as a mixture of sizes.

In general it may be said that in any market the coal obtainable at the lowest price is the most economical, provided the furnace equipment is suitable. If the furnace is not so designed as to permit the use of the cheaper coal, it should be changed.

The results of tests tend to show that, other conditions being equal, coals of similar composition are of value in proportion to the British thermal units in the coal as received—a basis on which, indeed, all coals may be valued approximately. It should be remembered, however, that the value of a coal for any particular plant is influenced by the fact that all furnaces are not equally suitable for burning the many grades of coal. Aside from this factor, coals may be compared in terms of the British thermal units obtained for 1 cent, or on the cost per million heat units.

In the purchase of coal, then, attention should be given to the character of the furnace equipment and the load; the character of coal best suited to the plant conditions; the number of heat units obtainable for a unit price; the cost of handling the coal and ash; and the possibility of burning the coal without smoke or other objectionable features.

SPECIFICATIONS IN USE.

As the result of a letter from President Roosevelt to the national advisory board on fuels and structural materials, calling attention to the need of a uniform and efficient basis for the purchase of the Government fuel supply, the following specification was drafted by engineers in the employ of the Government and approved by this board in March, 1907:

SPECIFICATIONS AND PROPOSALS FOR SUPPLYING COAL.

United States _____
 _____, 190__

PROPOSAL.

Sealed proposals will be received at this office until 2 o'clock p. m., _____, 190__, for supplying coal to the United States _____ building at _____ as follows:

The quantity of coal stated above is based upon the previous annual consumption, and proposals must be made upon the basis of a delivery of 10 per cent more or less than this amount, subject to the actual requirements of the service.

Proposals must be made on this form, and include all expenses incident to the delivery and stowage of the coal, which must be delivered in such quantities and at such times within the fiscal year ending June 30, 190__, as may be required.

Proposals must be accompanied by a deposit (certified check, when practicable, in favor of _____) amounting to 10 per cent of the aggregate amount of the bid submitted, as a guaranty that it is bona fide. Deposits will be returned to unsuccessful bidders immediately after award has been made, but the deposit of the successful bidder will be retained until after the coal shall have been delivered and final settlement made therefor, as security for the faithful performance of the terms of the contract, with the understanding that the whole or a part thereof may be used to liquidate the value of any deficiencies in quality or delivery that may arise under the terms of the contract.

When the amount of the contract exceeds \$10,000, a bond may be executed in the sum of 25 per cent of the contract amount, and in this case the deposit or certified check submitted with the proposal will be returned after approval of the bond.

The bids will be opened in the presence of the bidders, their representatives, or such of them as may attend, at the time and place above specified.

In determining the award of the contract, consideration will be given to the quality of the coal offered by the bidder, as well as the price per ton, and should it appear to be to the best interests of the Government to award the contract for supplying coal at a price higher than that named in lower bid or bids received, the award will be so made.

The right to reject any or all bids and to waive defects is expressly reserved by the Government.

DESCRIPTION OF COAL DESIRED.^a

Bids are desired on coal described as follows:

Coals containing more than the following percentages, based upon dry coal, will not be considered:

Ash -----	----per cent.
Volatile matter -----	----per cent.
Sulphur -----	----per cent.
Dust and fine coal as delivered at point of consumption ^b -----	----per cent.

DELIVERY.

The coal shall be delivered in such quantities and at such times as the Government may direct.

^a This information will be given by the Government as may be determined by boiler and furnace equipment, operating conditions, and the local market.

^b All coal which will pass through a $\frac{1}{4}$ -inch round-hole screen.

In this connection it may be stated that all the available storage capacity of the coal bunkers will be placed at the disposal of the contractor to facilitate delivery of coal under favorable conditions.

After verbal or written notice has been given to deliver coal under this contract, a further notice may be served in writing upon the contractor to make delivery of the coal so ordered within twenty-four hours after receipt of said second notice.

Should the contractor, for any reason, fail to comply with the second request, the Government will be at liberty to buy coal in the open market, and to charge against the contractor any excess in price of coal so purchased over the contract price.

SAMPLING.

Samples of the coal delivered will be taken by a representative of the Government.

In all cases where it is practicable, the coal will be sampled at the time it is being delivered to the building. In case of small deliveries, it may be necessary to take these samples from the yards or bins. The sample taken will in no case be less than the total of 100 pounds, to be selected proportionally from the lumps and fine coal, in order that it will in every respect truly represent the quantity of coal under consideration.

In order to minimize the loss in the original moisture content the gross sample will be pulverized as rapidly as possible until none of the fragments exceed one-half inch in diameter. The fine coal will then be mixed thoroughly and divided into four equal parts. Opposite quarters will be thrown out, and the remaining portions thoroughly mixed and again quartered, throwing out opposite quarters as before. This process will be continued as rapidly as possible until the final sample is reduced to such amount that all of the final sample thus obtained will be contained in the shipping can or jar and sealed air-tight.

The sample will then be forwarded to-----

If desired by the coal contractor, permission will be given to him, or his representative, to be present and witness the quartering and preparation of the final sample to be forwarded to the Government laboratories.

Immediately on receipt of the sample, it will be analyzed and tested by the Government, following the method adopted by the American Chemical Society, and using a bomb calorimeter. A copy of the result will be mailed to the contractor upon the completion thereof.

CAUSES FOR REJECTION.

A contract entered into under the terms of this specification shall not be binding if, as the result of a practical service test of reasonable duration, the coal fails to give satisfactory results owing to excessive clinkering or to a prohibitive amount of smoke.

It is understood that the coal delivered during the year will be of the same character as that specified by the contractor. It should, therefore, be supplied, as nearly as possible, from the same mine or group of mines.

Coal containing percentages of volatile matter, sulphur, and dust higher than the limits indicated on page 2 and coal containing a percentage of ash in excess of the maximum limits indicated in the following table will be subject to rejection.

In the case of coal which has been delivered and used for trial, or which has been consumed or remains on the premises at the time of the determination of

its quality, payment will be made therefor at a reduced price, computed under the terms of this specification.

Occasional deliveries containing ash up to the percentage indicated in the column of "Maximum limits for ash," on page 4, may be accepted. Frequent or continued failure to maintain the standard established by the contractor, however, will be considered sufficient cause for cancellation of the contract.

PRICE AND PAYMENT.^a

Payment will be made on the basis of the price named in the proposal for the coal specified therein, corrected for variations in heating value and ash, as shown by analysis, above and below the standard established by contractor in this proposal. For example, if the coal contains 2 per cent, more or less, British thermal units than the established standard, the price will be increased or decreased 2 per cent accordingly.

The price will also be further corrected for the percentages of ash. For all coal which by analysis contains less ash than that established in this proposal a premium of 1 cent per ton for each whole per cent less ash will be paid. An increase in the ash content of 2 per cent over the standard established by contractor will be tolerated without exacting a penalty for the excess of ash. When such excess exceeds 2 per cent above the standard established, deductions will be made from price paid per ton in accordance with following table:

Ash as established in proposal (per cent).	No deduc- tion for lim- its be- low.	Cents per ton to be deducted.							Maxi- mum limits for ash.
		2	4	7	12	18	25	35	
		Percentages of ash in dry coal.							
5.....	7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	12
6.....	8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	13
7.....	9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	14
8.....	10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	14
9.....	11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	15
10.....	12	12-13	13-14	14-15	15-16	16-17	17-18	-----	16
11.....	13	13-14	14-15	15-16	16-17	17-18	18-19	-----	16
12.....	14	14-15	15-16	16-17	17-18	18-19	19-20	-----	17
13.....	15	15-16	16-17	17-18	18-19	19-20	20-21	-----	18
14.....	16	16-17	17-18	18-19	19-20	20-21	21-22	-----	19
15.....	17	17-18	18-19	19-20	20-21	21-22	-----	-----	19
16.....	18	18-19	19-20	20-21	21-22	22-23	-----	-----	20
17.....	19	19-20	20-21	21-22	22-23	-----	-----	-----	21
18.....	20	20-21	21-22	22-23	-----	-----	-----	-----	22

Proposals to receive consideration must be submitted upon this form and contain all of the information requested.

-----, 190--

The undersigned hereby agree to furnish to the U. S. ----- building at -----, the coal described, in tons of 2,240 pounds

^a The economic value of a fuel is affected by the actual amount of combustible matter it contains, as determined by its heating value shown in British thermal units per pound of fuel, and also by other factors, among which is its ash content. The ash content not only lowers the heating value and decreases the capacity of the furnace, but also materially increases the cost of handling the coal, the labor of firing, and the cost of the removal of ashes, etc.

	Item No.---	Item No.---	Item No.---
<i>Description.</i>			
Commercial name.....			
Name of mine.....			
Location of mine.....			
Name of coal bed.....			
Size of coal (if coal is screened):			
Coal to pass through openings.....	inches } round. square.	inches } round. square.	inches } round. square.
Coal to pass over openings.....	inches } bar.	inches } bar.	inches } bar.
<i>Data to establish a basis for payment.</i>			
Per cent of ash in dry coal (method of American Chemical Society).....			
British thermal units in coal as delivered.....			
Price per ton (2,240 pounds).....			

Signature_____

Address_____

Name of corporation_____

Name of president_____

Name of secretary_____

Under what law (State) corporation is organized_____

If the dealer is not fairly familiar with the value of his coal, it may then be arranged to have him submit a properly selected sample with his bid, this sample to be analyzed by the Government and the results used as a standard in the contract. It is preferred, however, that the bidder use his own values.

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as mints, custom-houses, and post-offices located in all parts of the United States:

TREASURY DEPARTMENT, OFFICE OF THE SECRETARY,

Washington, March 27, 1907.

SIR: The accompanying specifications for coal are intended to give a clear description of the coal desired by the Government, and to secure a definite statement of the quality of coal offered by the bidder, with a view to using such statement as a basis for payment in connection with the stated price per ton. The plan is not new in its essential features, as it is an extension of a system already in force in the larger United States public buildings, and is similar to that employed by a number of private consumers.

What is desired is not necessarily the cheapest or the highest grade of coal per se, but the coal which will insure the greatest net economy in plant operation. In view of these facts the description of the coal inserted by the Government on page 2 of the accompanying specifications will receive careful consideration as the boiler and furnace conditions require. It is not expected that all deliveries will be absolutely uniform or agree exactly with the standard established by the contractor, but it is necessary that all deliveries shall be within the limits set by the Government.

The limits are wide enough to permit the use of the output of any mine or group of mines provided proper care is exercised in mining and picking out slate, bone, etc. With these points in mind it is only necessary for the bidder to select coal for each proposal which will meet the description given and permit deliveries within the limits set. The standard established by the contractor should be such as to require the least correction applying to deliveries for variation in heat units and ash from values established.

It is believed that the enforcement of the provisions of the specifications will operate equitably both with respect to the Government and to the contractor, and will guarantee adequate protection to each. Many coal dealers have already signified their willingness to furnish coal on this basis, and have commended as well as indorsed the method.

The application of this system will not only enable the award of a contract to be made in an equitable manner, but will also remove many of the usual causes for dispute as to the character and quality of the coal subsequently delivered, and provide a satisfactory basis for the correction of payments for differences in quality in favor of the party in whose interest it is due.

The system of sampling, analyzing, and testing coal delivered under the Government contracts will be under the supervision of the fuel-testing division of the Geological Survey, in order to insure reliability and impartiality.

The heating value expressed in British thermal units of coal containing approximately the same percentage of ash is essentially a direct measure of the actual value to the purchaser, and for this reason the specifications provide for an adjustment of payment in direct proportion to the variation in heat units in the coal as received. As the coal is weighed when delivered and the payments are based also upon the price per ton, it is necessary to determine the heating value of the coal in the condition, in which it is received, containing whatever moisture may be present at the time.

A further correction in payment will be made for variation of the ash in dry coal in order to take account of the cost of handling additional fuel and ash and its effect on the capacity of the boiler and furnace.

Respectfully,

A. F. STATTER,
Assistant Secretary.

On account of lack of information among the dealers in anthracite coal as to the heating value of the several sizes and kinds used by the Government, a number of contracts were let on the basis of the ash in dry coal. For the city of Washington these were worded in the same way as the regular specification, except the section relating to price and payment, which was as follows:

PRICE AND PAYMENT.

Payment will be made on the basis of the price named in the proposal for the coal specified, corrected for variations in ash as shown by analysis, above and below the standard established by the contractor.

For an increase or decrease up to 2 per cent in the ash content above or below the standard no correction will be made in the price. When the variation exceeds this allowance above or below the standard, corrections will be made in the price as follows:

For furnace, egg, stove, and chestnut sizes of coal, variations from the standard percentage of ash exceeding 2 and less than 2.5 above and below will result in the deduction or addition of 15 cents per ton. For each additional one-half of 1 per cent, or fraction thereof, 3 cents more per ton will be deducted or added.

For pea coal, variations from the standard percentage of ash exceeding 2 and less than 2.5 above and below will result in the deduction or addition of 10 cents per ton. For each additional one-half of 1 per cent, or fraction thereof, 2½ cents more per ton will be deducted or added.

For buckwheat and screenings, variations from the standard percentage of ash exceeding 2 and less than 2.5 above and below will result in the deduction or addition of 8 cents per ton. For each additional one-half of 1 per cent, or fraction thereof, 2 cents more per ton will be deducted or added.

The following specification is used by a few firms in Baltimore, Md.:

SPECIFICATIONS AND INFORMATION CONCERNING SUPPLY OF COAL FOR -----

Caution.—Bidders are directed to familiarize themselves with the storage facilities and local conditions, affecting the deliveries of coal, existing at the power house.

Method of determining quantity and quality.—Weights are subject to check either by measurement or by company scales. Any deficiency will be deducted from and any excess added to the bill.

Sampling will be done by a representative of the company and contractor may have a representative present.

Sample will be taken from each delivery and kept in hermetically sealed jars.

Detail of specifications.—Coal will be semibituminous and run-of-mine. It shall be dry, well picked, and free from excessive amounts of slate, pyrites, and dirt of any kind and shall have the following composition: Moisture, not over 1 per cent; volatile carbon, not over 20 per cent; ash, not over 7 per cent; sulphur, not over 1 per cent.

ADJUSTMENTS.

Additions.—If the coal has less than 1 per cent moisture, the deficit per cent less than 1 per cent will be added to the bill. If the coal has less than 20 per cent volatile carbon, the deficit per cent less than 20 per cent will be multiplied by 2 and added to the bill. If the coal has less than 7 per cent ash, the deficit per cent less than 7 per cent will be multiplied by 3 and added to the bill.

Deductions.—If the coal contains more than 1 per cent moisture, the excess per cent above 1 per cent will be deducted from the bill. If the coal contains more than 20 per cent volatile carbon, the excess per cent above 20 per cent will be multiplied by 2 and deducted from the bill. If the coal contains more than 7 per cent ash, the excess per cent above 7 per cent will be multiplied by 3 and deducted from the bill.

The following are the essential features of the contracts on which a Chicago company is said to purchase and inspect nearly 1,000,000 tons of coal for its clients in Chicago, Indianapolis, Minneapolis, St. Louis, and other cities:

I. The company agrees to furnish and deliver to the consumer ----- at such times and in such quantities as ordered by the consumer for consumption at said premises during the term hereof, at the consumer's option, either or all of the kinds of coal described below; said coals to average the following assays:

Kind of coal.....	-----	-----	-----
Of size passing through screen having circular perforations in diameter.....	---- inches	---- inches	---- inches
Of size passing over a screen having circular perforations in diameter.....	---- inches	---- inches	---- inches
Per cent of moisture in coal as delivered.....	-----	-----	-----
Per cent of ash in coal as delivered.....	-----	-----	-----
British thermal units per pound of dry coal.....	-----	-----	-----
From following county.....	-----	-----	-----
From following State.....	-----	-----	-----

Coal of the above respective descriptions and specified assays (not average assays) to be hereinafter known as the contract grade of the respective kinds.

II. The consumer agrees to purchase from the company all the coal required for consumption at said premises during the term of said contract, except as set forth in Paragraph III below, and to pay the company for each ton of 2,000 pounds avoirdupois of coal delivered and accepted in accordance with all the terms of this contract at the following contract rate per ton for coal of each respective contract grade, at which rates the company will deliver the following respective numbers of British thermal units for 1 cent, the contract guaranty:

Kind of coal.	Contract rate per ton.	Contract guaranty.
-----	\$-----	equal to ----- net B. t. u. for 1 cent.
-----	\$-----	equal to ----- net B. t. u. for 1 cent.
-----	\$-----	equal to ----- net B. t. u. for 1 cent.

Said net British thermal units for 1 cent being in each case determined as follows: Multiply the number of British thermal units per pound of dry coal by the per cent of moisture (expressed in decimals), subtract the product so found from the number of British thermal units per pound of dry coal, multiply the remainder by 2,000, and divide this product by the contract rate per ton (expressed in cents) plus one-half of the ash percentage (expressed as cents).

III. It is provided that the consumer may purchase for consumption at said premises coal other than herein contracted for, for test purposes, it being un-

derstood that the total of such coal so purchased shall not exceed 5 per cent of the total consumption during the term of this contract.

IV. It is understood that the company may deliver coal hereunder containing as high as 3 per cent more ash and as high as 3 per cent more moisture and as low as 500 fewer British thermal units per pound dry than specified above for contract grades.

V. Should any coal delivered hereunder contain more than the per cent of ash or moisture or fewer than the number of British thermal units per pound dry allowed under Paragraph IV hereof, the consumer may, at its option, either accept or reject same.

VI. All coal accepted hereunder shall be paid for monthly at a price per ton determined by taking the average of the delivered values obtained from the analyses of all the samples taken during that month, said delivered value in each case being obtained as follows: Multiply the number of British thermal units delivered per pound of dry coal by the per cent of moisture delivered (expressed in decimals), subtract the product so found from the number of British thermal units delivered per pound of dry coal, multiply the remainder by 2,000, divide this product by the contract guaranty, and from this quotient (expressed as dollars and cents) subtract one-half of the ash percentage delivered (expressed as cents).

In Cleveland, Ohio, coal is purchased for the waterworks on the basis of its heating value. The standard agreed upon is 13,624 British thermal units and was established as the result of analysis and tests made on a sample furnished by the dealer.

The following are the essential features of the specifications used by the Interborough Rapid Transit Company of New York in purchasing about 30,000 tons of coal each month for use in its plants, which are among the largest in the United States:

PRELIMINARY SPECIFICATIONS FOR BITUMINOUS COAL FOR THE INTERBOROUGH RAPID TRANSIT COMPANY.

Coal must be a good steam, caking, run-of-mine, bituminous coal free from all dirt and excessive dust, a dry sample of which will approximate the company's standard in heat value and analysis, as follows: Carbon, 71; volatile matter, 20; ash, 9; British thermal units, 14,100; sulphur, 1.50.

A small quantity of coal will be taken from each weighing hopper just before the hopper is dumped while the lighter is being unloaded. These quantities will be thrown into a receptacle provided for the purpose, and when the lighter is empty the contents of the receptacle will be thoroughly mixed, and a sample of this mixture will be taken for chemical analysis. This average sample of coal will be labeled and held for one week after the unloading of the lighter. The sample taken from the mixture for test will be analyzed as soon as possible after being taken. No other sample will be recognized.

Tests of sample taken from average sample will be made by the company's chemist under the supervision of the superintendent. Should the contractor question the results of the company's test (a copy of which will be mailed to him), the company will, if requested by the contractor within three days after copy of test has been mailed to him, forward sufficient quantity of the average sample taken from each weighing hopper to any laboratory in the city of New York which may be agreed upon by the superintendent and the contractor, and have said sample analyzed by it, and the results obtained from this second test will be considered as final and conclusive. In case the disputed values, as ob-

tained in the company's test, shall be found by the second test to be 2 per cent or less in error, then the cost of said second test shall be borne by the contractor; but if the disputed values shall be found to be more than 2 per cent in error, then the cost of said second test shall be borne by the company.

Should there be no question raised by the contractor within the three days specified, as to the values of the first analysis, the average sample of coal will be destroyed at the end of seven days from date of discharge of coal from lighter. Should a second test be made of coal taken from any lighter as herein provided, then any penalties to be made as set forth in paragraph under "Penalties" will be based on the results as obtained from the second test.

The price to be paid by the company per ton per lighter of coal will be based on a table of heat values for excess or deficiency of its standard, but subject to deductions as given in the section under "Penalized coal," including excess of ash, volatile matter, sulphur, or dust, or less than the minimum amount required to be contained in any lighter, for coal which shows results less than the company's standard.

Premiums or deductions are based on a rate of 1 cent per ton for a variation of 50 British thermal units per pound of coal, as indicated in a table a few items of which are given below:

Table for B. t. u. values.

For coal in any lighter which is found by test to contain, per pound of dry coal, from—

15,501 and above.....	28 cents per ton above standard.
15,101 to 15,150, both inclusive.....	20 cents per ton above standard.
14,601 to 14,650, both inclusive.....	10 cents per ton above standard.
14,101 to 14,150, both inclusive.....	Standard.
13,601 to 13,650, both inclusive.....	10 cents per ton below standard.
13,101 to 13,150, both inclusive.....	20 cents per ton below standard.
12,101 to 12,150, both inclusive.....	40 cents per ton below standard.

No lighter of coal will be accepted which, by trial, in the judgment of the superintendent, contains an excessive amount of dry coal dust. The decision of the superintendent will be final in this respect. Coal taken from such lighter for trial will be subject to the special deduction set forth under "Penalized coal," but paid for in all other respects as herein provided.

Coal which is shown by analysis to contain less than 20 per cent of volatile matter, 9 per cent of ash, or 1.50 per cent of sulphur, will be accepted without a deduction from the bidder's price, plus or minus an amount for excess or deficiency of British thermal unit value, as herein provided. Where the analysis gives amounts for any or all elements in excess of these quantities, deductions will be made from the bidder's price in accordance with the tables of values of volatile matter, ash, and sulphur below given, plus or minus the amount for excess or deficiency of the standard British thermal unit value, in addition to any other deductions which may be made as herein provided.

Table of deductions for volatile matter.

For coal in any lighter which is found by test to contain, per pound of dry coal—

Over 20 per cent and less than 21 per cent.....	2 cents per ton.
* * * * *	
Over 22.5 per cent and less than 23 per cent.....	12 cents per ton.
* * * * *	
24 per cent and over.....	18 cents per ton.

This table is made for a difference of each one-half of 1 per cent and the deductions are at the rate of 4 cents for each 1 per cent of volatile matter.

Table of deductions for ash.

For coal in any lighter which is found by test to contain, per pound of dry coal—

Over 9 per cent and less than 9.5 per cent.....	2 cents per ton.
* * * * * *	
Over 11.5 per cent and less than 12.....	12 cents per ton.
* * * * * *	
13.5 per cent and over.....	23 cents per ton.

This table is made for each difference of one-half of 1 per cent and at the rate of 4 cents for each 1 per cent increase in the ash.

Table of deductions for sulphur.

For coal in any lighter which is found by test to contain, per pound of dry coal—

Over 1.50 per cent and less than 1.75 per cent.....	6 cents per ton.
* * * * * *	
Over 2 per cent and less than 2.25 per cent.....	10 cents per ton.
* * * * * *	
2.50 and over.....	20 cents per ton.

This table is made out for each difference of one-fourth of 1 per cent and at a diminishing rate.

Should any lighter of coal delivered at the company's docks contain less than 700 tons, a deduction of 7 cents per ton will be made from the price as determined by the British thermal unit value and analysis, in addition to any other penalty provided for herein. Should any lighter of coal delivered at the company's docks be rejected by the superintendent on account of excessive amount of coal dust, then a deduction of 25 cents per ton will be made from the price as determined by the British thermal unit value and analysis, for the coal taken from said lighter, in addition to any other penalty which may be made as herein provided. Should any lighter of coal be delivered in other than self-trimming lighters as herein provided, a deduction of 7 cents per ton will be made from the price as determined by the British thermal unit value and analysis, exclusive of any other penalty which may be made as herein provided.

The contractor's bill of lading will be checked by the company's scales. Should there be a deficiency of 1 per cent or more between the bill of lading and the company's weights, then the company's weights will be taken as correct.

When the contractor has been notified by the company to deliver coal under this contract, a further notice may be given requiring the contractor to make delivery of the coal so ordered within twelve hours after the receipt of said second notice. Should the contractor, for any reason, fail to deliver the coal so ordered within twelve hours after the receipt of said second notice and in accordance with the requirements therein as to place of delivery, the company shall be at liberty to buy coal in the open market, and the contractor will make good to the company any difference there may be between the price paid by the company for said coal in open market and the price the company would have paid to the contractor had the coal been delivered by it in accordance with

the requirements of said notices from the company, or said difference may be deducted from any money then due or thereafter to become due to the contractor under the contract to be entered into.

METHODS OF SAMPLING AND TESTING.

In connection with the Survey's study of the coal deposits of the country and the best methods to prevent waste in mining and utilizing the coal supply, trained inspectors have visited nearly 300 mines in 23 States, taking two or more samples from each mine. A study of the analyses of these samples and of samples taken from cars shipped from 175 of the same mines shows that the mine sample is in most instances better than the average of the coal as shipped in cars. On the average the coal delivered contains about one-third more ash than the mine sample taken in accordance with the instructions to the miners regarding the rejection of slate and impurities. This difference is due to the failure of the miners to follow these instructions in getting out coal for shipment. The samples collected by the Government inspectors from the mines almost invariably show a higher moisture content than is usually obtained in commercial sampling, because of the precaution taken to have the sample represent the coal in the mine.*

Mine samples when properly taken indicate the general character of the coal and enable one to judge of its probable value for any definite purpose.

Samples taken from the cars should not be limited to a few shovelfuls of coal from the top of the car, because the heavier pieces gradually work down toward the bottom. Some samples taken at the bottom of a car have shown as much as 8 per cent more ash than the coal at the top. The moisture also may vary from top to bottom, depending on the weather. The only way to get a fair sample is to take a number of shovelfuls of coal from various points in the car, so as to procure a representative portion of the coal from top to bottom and from end to end.

Bituminous coal when exposed to the air gradually depreciates in heating value, owing to losses of volatile matter, but aside from this loss there should be the same total number of heat units in a car of coal when it reaches its destination as when it started. If rain falls on the coal it will become heavier and a greater number of pounds will be delivered, but each pound will have a correspondingly lower heat value. On the other hand, if the weather is fair and the coal dries out on the way, it will weigh less and the heating value of each pound will be correspondingly higher. In other words, under a specification such as is used by the Government, neither the dealer

* A description of the method of mine sampling is given in Bull. U. S. Geol. Survey No. 290, 1906, pp. 17-18. See also Bull. No. 316, 1907, pp. 486-517.

nor the purchaser will gain or lose by change in the moisture content of the coal between the time it is weighed at the mine and the time it is weighed on delivery. The price per ton will be correspondingly lower if the coal is wet and higher if the coal is dry.

In order to determine the maximum variation in moisture in several sizes of anthracite coal the following experiments were made: The coal was soaked in water to allow it to absorb as much moisture as possible, the result representing the extreme conditions due to rains or other causes. Each sample was then weighed and allowed to dry in a room exposed to the air. When this sample ceased to lose moisture it was assumed to be air dried, which represents the condition of least moisture to be expected in a delivery of coal. The results are summarized in the following table:

Experiments to determine possible variations of moisture in anthracite coal during shipment.

	Furnace.	Pea.	Buck-wheat.
Number of samples used in experiment.....	13	10	12
Number of hours dried in air at ordinary room temperature.....	0.5 to 24	24	24
Total moisture in thoroughly wet coal.....per cent.....	5.12	5.74	8.44
Moisture in air-dried samples.....do.....	3.58	1.84	2.24
Loss of moisture.....do.....	.73 to 1.54	3.1 to 3.9	4.5 to 6.2
Percentage of maximum variation in moisture from wet to air-dried coal.....	30	68	74

The air-dried anthracite still contains from 1.8 to 3.6 per cent of moisture. Moisture in air-dried coal varies with the weather, just as it does in wood.

The moisture in air-dried bituminous coals depends on the character of the coal. It is about 1 per cent in West Virginia coal and about 7 per cent in Illinois coal. The moisture in the same Illinois coal delivered may range from 7 to 17 per cent.

Owing to these variations some method should be used to correct for the difference in moisture in coals of different character.

The following suggestions are presented for the guidance of those who wish to send samples to a laboratory for analysis:

If samples are taken at the buildings as the coal is delivered, it will usually be satisfactory to take one shovelful of coal from each third or fifth wagonload, the load being selected without the knowledge of the driver. It must be kept in mind that the main object is to obtain a portion of coal which represents as nearly as possible the entire delivery. The sample should contain about the same proportion of lump and fine coal as exists in the shipment as a whole. The practice of taking a shovelful near the bottom of the pile should be avoided, as the larger lumps of coal roll down and collect near the bottom and such a sample will not truly represent the coal.

These samples should be immediately deposited in a metal receptacle having a tight-fitting cover and provided with a first-class lock. Except when samples are being deposited or when the contents are being quartered down, this receptacle should be securely locked and the key held by a responsible employee. The receptacle should be placed in a comparatively cool location to avoid loss of moisture in the coal. When it becomes filled, or at the end of the sampling period, the contents should be emptied on a clean, dry floor, in a cone-shaped pile. The larger lumps should be broken down by a coal maul or sledge, and the pile re-formed and quartered into four equal parts, a shovel or board being used to separate the four sections. Two opposite sections should then be rejected and the remaining two again mixed, broken down, and re-formed into a pile to be quartered as before. This process should be continued until the lumps are no larger than pea size, and a quart sample is finally procured. The samples should then immediately be placed in suitable receptacles for shipping and sealed air-tight. The Geological Survey inspectors use a metal can 3 inches in diameter and 9 inches high, with a screw cap 2 inches in diameter, for making shipments to the chemical laboratory. These cans are sealed air-tight by winding adhesive electrical tape around the joint of the screw cap. Each can holds about a quart. or 2 pounds of coal.

The process of quartering down and preparing samples for shipment to the chemical laboratory for analysis should be carried on as rapidly as possible to avoid loss of moisture. The samples should be forwarded promptly and notice of shipment sent under separate cover. Receptacles should be marked plainly on the outside, and a corresponding number or description should be placed inside. A complete record of all deliveries should be kept, showing dates, names of contractor, kind of coal, total weight delivered, condition of coal (wet or dry), and any other particulars of importance.

The procedure at the chemical laboratory of the Geological Survey testing plant is described in Survey Bulletin No. 261. The samples are crushed and ground to a fine powder. and then analyzed and tested.

Persons not experienced in taking samples have a tendency to select a sample better than the average. In many cases a lump of coal is broken and shipped in a cloth sack to the laboratory. This allows the moisture to dry out; moreover, the lump selected is usually free from layers of slate and impurities and of course then represents the best coal in the lot, and shows a higher value than can be expected to hold throughout the coal delivered.

The preceding statements show that the purchaser should usually have the quality determined on the basis of coal "as received," in order to correct any excess or deficiency in the moisture content.

ANALYSES OF COALS DELIVERED TO THE GOVERNMENT.

The following tables, giving the results of tests made by the Geological Survey on coal delivered to the Government Departments, are submitted in response to numerous recent requests for information regarding the quality of coal which may be expected, and the variations in quality which may be found from month to month in coal delivered by the same dealer and presumably from the same mine or group of mines:

Average analyses of anthracite coal delivered to all Government buildings in Washington, D. C., from December 15, 1906, to April 26, 1907.^a

	Furnace.	Egg.	Pea.	Buck-wheat.
Dry coal:				
Volatile matter.....	2.42	3.10	3.02	2.42
Fixed carbon.....	87.14	86.33	80.94	79.53
Ash.....	10.44	10.57	16.04	18.06
	100.00	100.00	100.00	100.00
Sulphur ^b	.79	.98	.80	.68
B. t. u.....	13,408	13,523	12,487	12,107
Coal as received:				
Moisture.....	4.08	4.16	4.81	5.09
B. t. u.....	12,861	12,961	11,883	11,483

^a Payment not based on chemical analysis.

^b Separately determined.

Analyses of anthracite furnace coal delivered during 1907 to a Government building in Washington, D. C.^a

	Jan. 29.	Feb. 2.	Feb. 4.	Feb. 9.	Feb. 11.	Feb. 12.	Feb. 14.	Feb. 15.
Dry coal:								
Volatile matter.....	2.66	2.85	3.32	2.53	3.06	2.56	2.99	2.09
Fixed carbon.....	86.38	86.34	87.66	86.65	85.45	86.69	86.63	86.15
Ash.....	10.96	10.81	9.02	10.82	11.49	10.75	10.38	11.76
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.78	.78	.78	.78	.69	.84	.83	.95
B. t. u.....	13,297	13,435	13,764	13,418	13,282	13,360	13,427	13,168
Coal as received:								
Moisture.....	4.13	4.19	4.67	4.41	3.83	5.83	4.99	4.33
B. t. u.....	12,749	12,874	13,121	12,826	12,773	12,582	12,757	12,596

	Feb. 23.	Feb. 25.	Feb. 26.	Feb. 27.	Feb. 28.	Mar. 13.	Average.
Dry coal:							
Volatile matter.....	1.56	1.62	2.00	3.34	2.84	2.13	2.51
Fixed carbon.....	87.96	87.77	88.61	85.12	85.37	87.22	86.74
Ash.....	10.48	10.61	9.39	10.54	11.79	10.65	10.75
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.93	.78	.74	.87	.86	.79	.81
B. t. u.....	13,094	13,346	13,655	13,390	13,166	13,421	13,363
Coal as received:							
Moisture.....	3.06	3.50	3.93	4.50	5.60	2.12	4.24
B. t. u.....	12,694	12,879	13,118	12,787	12,429	13,136	12,796

^a Contract for 4,500 tons. Payment not based on chemical analysis.

^b Separately determined.

Analyses of anthracite egg coal delivered during 1907 to a Government building in Washington, D. C.^a

	Jan. 29.	Jan. 31.	Feb. 5.	Feb. 9.	Feb. 11.	Feb. 13.	Feb. 14.	Feb. 15.	Feb. 21.
Dry coal:									
Volatile matter.....	2.96	2.83	2.57	3.90	3.17	3.53	3.05	3.69	2.86
Fixed carbon.....	86.29	86.58	86.27	95.39	86.76	86.04	86.90	86.36	85.72
Ash.....	10.75	11.59	11.16	10.71	10.07	10.43	10.06	9.95	11.42
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.98	.92	.86	1.15	1.06	.96	1.04	1.12	.97
B. t. u.	13,423	13,279	13,336	13,496	13,588	13,614	13,738	13,649	13,328
Coal as received:									
Moisture.....	4.18	4.34	3.38	4.01	4.11	4.17	4.73	4.51	4.23
B. t. u.	12,863	12,708	12,886	12,953	13,030	13,045	13,688	13,034	12,764

	Feb. 23.	Feb. 25.	Feb. 26.	Feb. 28.	Mar. 3.	Apr. 2.	Apr. 19.	Apr. 24.	Average.
Dry coal:									
Volatile matter.....	3.60	3.62	3.15	3.22	2.86	3.01	2.89	3.19	3.41
Fixed carbon.....	87.99	86.00	86.68	86.46	85.58	87.59	86.93	86.36	86.99
Ash.....	9.40	10.38	10.27	10.32	11.61	9.40	10.18	10.45	9.60
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.94	.98	.99	1.13	1.02	.99	1.08	1.01	.99
B. t. u.	13,798	13,643	13,608	13,617	13,293	13,667	13,672	13,558	13,744
Coal as received:									
Moisture.....	4.15	3.64	4.07	4.13	3.15	4.08	3.92	4.07	4.15
B. t. u.	13,174	13,291	13,064	13,065	12,874	13,100	13,136	13,006	13,174

^a Contract for 9,000 tons. Payment not based on chemical analysis.

^b Separately determined.

Analyses of anthracite pea coal delivered during 1906-7 to a Government building in Washington, D. C.^a

	Dec. 22.	Jan. 9.	Jan. 24.	Jan. 28.	Jan. 31.	Feb. 5.	Feb. 6.	Feb. 7.	Feb. 11.	Feb. 12.
Dry coal:										
Volatile matter.....	3.38	2.58	3.73	3.07	3.33	3.39	4.06	3.30	3.77	3.23
Fixed carbon.....	80.51	84.17	81.34	82.16	80.22	80.80	79.37	80.57	79.95	80.00
Ash.....	16.11	13.25	14.93	14.77	16.45	15.81	16.57	16.13	16.28	16.68
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.60	.67	.99	1.01	.87	.78	.78	.77	.71	.68
B. t. u.	12,460	12,883	12,877	12,835	12,583	12,623	12,555	12,552	12,418	12,384
Coal as received:										
Moisture.....	4.35	4.62	5.24	3.40	5.62	5.86	4.27	5.50	6.04	5.78
B. t. u.	11,919	12,286	12,203	12,399	11,876	11,883	12,019	11,862	11,668	11,688

	Feb. 13.	Feb. 14.	Feb. 18.	Feb. 19.	Feb. 25.	Mar. 18.	Apr. 1.	Apr. 8.	Apr. 12.	Average.
Dry coal:										
Volatile matter.....	2.27	2.32	3.50	3.06	2.13	2.50	2.49	2.51	2.74	3.02
Fixed carbon.....	82.45	80.45	78.75	81.35	83.24	80.83	79.45	81.00	81.24	80.94
Ash.....	15.28	17.23	17.75	15.59	14.63	16.67	18.06	16.49	16.02	16.04
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.92	.86	1.05	.89	.68	.80	.69	.64	.77	.80
B. t. u.	12,300	12,317	12,160	12,464	12,627	12,410	12,088	12,284	12,479	12,487
Coal as received:										
Moisture.....	5.20	4.92	4.58	5.23	5.02	3.85	2.97	5.18	3.77	4.81
B. t. u.	11,660	11,711	11,603	11,812	11,993	11,932	11,680	11,649	12,008	11,886

^a Contract for 6,000 tons. Payment not based on chemical analysis.

^b Separately determined.

Analyses of anthracite buckwheat coal delivered during 1906-7 to a Government building in Washington, D. C.^a

	Dec. 18.	Jan. 15.	Jan. 16.	Jan. 22.	Jan. 23.	Jan. 28.	Jan. 31.	Feb. 4.
Dry coal:								
Volatile matter.....	2.50	1.93	2.21	2.49	2.41	1.98	3.23	2.89
Fixed carbon.....	80.34	82.40	80.94	80.72	76.32	79.38	78.61	80.57
Ash.....	17.16	15.67	16.35	16.79	21.27	18.64	18.16	16.54
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.63	.73	.68	.67	.67	.67	.67	.60
B. t. u.....	12,245	12,475	12,314	12,570	11,574	11,970	11,843	12,265
Coal as received:								
Moisture.....	4.79	5.59	4.47	4.93	5.32	4.38	5.13	4.69
B. t. u.....	11,659	11,776	11,763	11,755	10,959	11,445	11,236	11,681

	Feb. 7.	Feb. 12.	Feb. 15.	Mar. 2.	Mar. 20.	Apr. 3.	Apr. 13.	Average
Dry coal:								
Volatile matter.....	1.78	2.66	2.59	2.07	2.87	2.11	2.62	2.42
Fixed carbon.....	76.91	80.03	79.34	76.90	81.56	79.52	79.36	79.53
Ash.....	21.31	17.31	18.07	21.03	15.57	18.37	18.02	18.05
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^b	.67	.70	.77	.70	.62	.77	.69	.68
B. t. u.....	11,635	12,350	12,098	11,749	12,545	12,109	12,071	12,107
Coal as received:								
Moisture.....	5.51	5.36	5.57	6.10	4.60	4.31	5.64	5.09
B. t. u.....	10,993	11,609	11,016	11,032	11,968	11,587	11,390	11,485

^a Contract for 5,000 tons. Payment not based on chemical analysis.

^b Separately determined.

Analyses of bituminous coal delivered during 1906-7 to a Government building in Washington, D. C., as being run-of-mine from Georges Creek.

	Dec. 27.	Jan. 3.	Jan. 22.	Jan. 23.	Jan. 30.	Feb. 6.
Dry coal:						
Volatile matter.....	16.84	16.24	17.26	17.08	16.43	16.66
Fixed carbon.....	73.01	75.07	75.27	76.23	75.11	75.57
Ash.....	10.15	8.69	7.47	6.74	8.46	7.77
	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur ^a	1.02	.93	1.03	1.08	.80	.94
B. t. u.....	14,017	14,364	14,636	14,764	14,441	14,586
Coal as received:						
Moisture.....	4.80	2.77	3.43	4.22	3.09	3.73
B. t. u.....	13,343	13,966	14,134	14,141	13,995	14,040

	Feb. 9.	Feb. 15.	Mar. 28.	Feb. 21.	Apr. 15.
Dry coal:					
Volatile matter.....	16.21	15.77	16.29	16.42	15.76
Fixed carbon.....	74.99	75.12	74.55	74.79	76.89
Ash.....	8.80	9.11	9.16	8.79	7.35
	100.00	100.00	100.00	100.00	100.00
Sulphur ^a	.95	.99	1.08	.95	.95
B. t. u.....	14,317	14,308	14,264	14,352	14,632
Coal as received:					
Moisture.....	4.07	8.12	3.15	2.94	2.97
B. t. u.....	13,734	13,862	13,815	13,980	14,197

^a Separately determined.

SOME PUBLICATIONS ON COAL.

The following are a few of the Survey publications on coal. A more complete list is given in Bulletin No. 316, pages 518-532. The reports here named are now available for distribution. Others are in press and still others are in preparation. Applications for these reports, except for Bulletin No. 261 and Professional Paper No. 48, should be addressed to The Director, United States Geological Survey, Washington, D. C.

Bulletin No. 261. Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1905. 172 pp. Out of stock. Can be obtained by sending 10 cents in cash to the Superintendent of Documents, Washington, D. C.

Professional Paper No. 48. Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1906. In three parts. 1492 pp., 13 pls. Out of stock. Can be obtained by sending \$1.50 in cash to the Superintendent of Documents, Washington, D. C.

Bulletin No. 290. Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905. By J. A. Holmes. 1906. 240 pp.

Bulletin No. 323. Experimental work conducted in the chemical laboratory of the fuel-testing plant, St. Louis, January 1, 1905, to July 31, 1906. By N. W. Lord. 1907. 49 pp.

Bulletin No. 325. A study of four hundred steaming tests made at the fuel-testing plant, St. Louis, Mo., 1904, 1905, and 1906. By L. P. Breckenridge. 1907. 196 pp.

A few miscellaneous references of special interest may be given, as follows:

Bement, A. The testing of coal. Western Society of Engineers.

Electrical World. Editorial, April 6, 1907.

Engineering Record. Editorial, April 13, 1907.

Parr, S. W. Composition and character of coals. Bulletin No. 3, Illinois Geological Survey, Urbana, Ill.

Preliminary report of committee on coal analysis. Journal of the American Chemical Society, vol. 20, 1898.

Report of the committee on coal analysis. Journal of the American Chemical Society, vol. 21, 1899.

Voorhees, S. S. Analysis of coal. American Society for Testing Materials, 1907.

Woodwell, J. E. The purchase of coal. American Society for Testing Materials, 1907; Mines and Minerals, September, 1907.

CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 339.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

Most of the above publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except classes 2, 7, and 8), on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they can be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports, Q, Fuels; R, Structural materials. This paper is the tenth in Series Q, the complete list of which follows (PP=Professional Paper; B=Bulletin):

SERIES Q, FUELS.

- B 261. Preliminary report of the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1906. 172 pp.
- PP 48. Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1906. 3 parts. 1,492 pp., 13 pls.
- B 290. Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905, by J. A. Holmes. 1906. 240 pp.
- B 323. Experimental work conducted in the chemical laboratory of the United States fuel-testing plant at St. Louis, Mo., January 1, 1905, to July 31, 1906, by N. W. Lord. 1907. 49 pp.
- B 325. A study of four hundred steaming tests made at the fuel-testing plant, St. Louis, Mo., in 1904, 1905, and 1906, by L. P. Breckenridge. 1907. 196 pp.
- B 332. Report of the United States fuel-testing plant at St. Louis, Mo., January 1, 1906, to July 1, 1907, Joseph A. Holmes in charge. 1908. — pp.
- B 333. Coal-mine accidents: their causes and prevention; a preliminary statistical report, by Clarence Hall and W. O. Snelling, with an introduction by J. A. Holmes. 1907. 21 pp.
- B. 334. The burning of coal without smoke in boiler plants, a preliminary report, by D. T. Randall. 1908. 26 pp.
- B 336. Washing and coking tests of coal and cupola tests of coke, by Richard Moldenke, A. W. Belden, and G. R. Delamater. 1908. — pp.
- B 339. The purchase of coal under Government and commercial specifications, on the basis of its heating value, by D. T. Randall. 1908. 27 pp.

Correspondence should be addressed to

THE DIRECTOR,

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WASHINGTON, D. C.

JANUARY, 1908.

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